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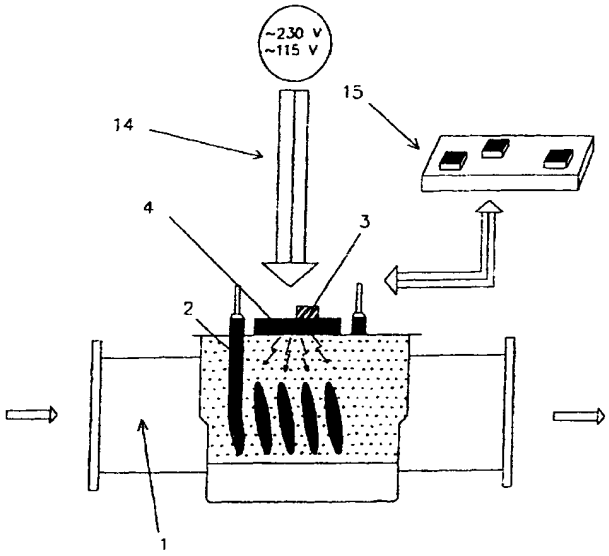
(54) Title: IMPROVEMENT IN A THROUGH-FLOW FLUID HEATER TUBE



(57) Abstract: Through-flow fluid heater tube comprising a conduit adapted to convey the fluid to be heated, an electric heating element controlled by a Triac, a related heat-sink arrangement, control circuits adapted to drive said Triac, a connection joining said electric heating element to the power-supply mains via said Triac, in which said heat-sink arrangement is applied on to the outside of said through-flow heater tube. The current regulation device is energized directly from the power-supply mains and said control and driving circuits supply a low-voltage regulating current to said current regulation device.

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IMPROVEMENT IN A THROUGH-FLOW FLUID HEATER TUBE

DESCRIPTION

The present invention relates to a tube provided with an electric heating element adapted to heat up the fluid flowing through said tube.

More particularly, the present invention relates to an electric heating element that is associated to a section of such a tube and is adapted to be energized by an appropriate, preferably electronic control circuitry.

Owing to reasons connected with the need for an adequate heat conductivity to be ensured along with an adequate heat resistance, these tubes are usually made of an appropriate metal, or metal alloy, although this fact is of no relevance as far as the present invention is concerned and is indicated here to the sole purpose of better elucidating the context and actual scope of the present invention.

Widely known in the art are tubes which are adapted to convey fluids, in particular water, and are provided with electric heating elements that are wound so as to form a plurality of turns, or coils,

around said tubes, in such a manner as to ensure that the thermal energy generated by said heating elements is transferred to the walls of the tube and, from here, to the liquid flowing therethrough.

In general, the electric energy supplied to said electric heating elements to energize the same is not applied in a continuous manner, but is rather supplied in an intermittent manner in accordance with the actual operating requirements, and is regulated by appropriate electronic control and switching circuits.

To such a purpose, owing to reasons that are largely known to those skilled in the art, and that shall therefore not be dealt with any further here, use is largely made of a suitably driven device known as Triac (i.e. Triode Alternating Current Switch).

The use of such a Triac device, although ensuring a maximum extent of safety and reliability, is however connected with a major drawback: a Triac is in fact a power switching device and, during its operation, it takes up energy which must of course be duly dissipated, so that it tends to heat up quire rapidly to fully unacceptable temperature values that are fully incompatible with its correct operation.

In view of reducing the extent of such a problem, it is a largely known practice to have the Triac applied into close contact with an appropriate metal cool-down heat-sink arrangement adapted to dissipate the heat generated by the Triac itself. Owing to reasons of compact construction and uncomplicated, straight circuit arrangements, this Triac device and the related heat-sink arrangement are inserted in the same board containing the circuits and the electronic driving and control components for the same Triac.

However, this solution does not prove fully satisfactory, either, since it still has some drawbacks, i.e.:

- a first drawback is of an economic, production-related nature, and lies in the fact that such a metal cool-down heat-sink arrangement is a rather expensive component part;

- a second drawback is a consequence of the kind of operation of the Triac itself; since the latter dissipates and, therefore, uses energy that is not used to any other practical purpose, such a usage tends to aggravate the overall efficiency of the tube-control assembly, with rather costly consequences considering how much electric energy actually costs, especially when it is used in quite considerable amounts for such low-value applications as the heating of fluids;

- a third drawback is a consequence of following circumstance: since the power-supply voltage is 230 V in Europe, while it is 115 V in the United States, in order to be able to generate the same heating power with a same through-flow heater tube, the need arises in the US for a current to flow through said tube which is approximately double as high as the one needed in Europe (owing to the rule according to which $P=V \cdot I$, i.e. the current must double when the voltage is halved).

This practically means that, if a same Triac is to be used with a same heater tube in said two different regions of the world, the Triac should be capable of dissipating in the US a power which is approximately four times as high as the power it would have to dissipate in Europe (since it is also R_{triac}=constant and $P= R_{triac} \cdot I^2$), with easily imaginable practical and functional consequences.

On the other hand, if the decision is taken to develop and use a power control circuitry that is specifically dedicated to the US market,

this would of course occur at the expense of manufacturing standardization, with resulting burdens that are well known to all those skilled in the art.

It would therefore be desirable, and it is actually a main object of the present invention to provide a through-flow fluid heating tube and related control circuits, including the power control circuit, which do away with the afore-cited drawback and are capable of being manufactured in a low-cost, simple manner using readily available materials and techniques.

According to the present invention, this aim, along with further ones that will become apparent in the course of the following description, is reached in a kind of through-flow heater tube that is made and operates according to the characteristics as recited in the appended claims.

The present invention may be implemented in the form of a preferred, although not sole embodiment that will be described in greater detail and illustrated below by mere way of non-limiting example with reference to the accompanying drawings, in which:

- Figures 1a and 1b are schematic views of the power-supply module and a heater tube provided with electric heating element according to the prior art, respectively;

- Figure 2 illustrates three schematic representations of a first embodiment of a through-flow heater tube according to the present invention;

- Figure 3 is a view showing symbolically a combination of component parts of a through-flow heater tube arrangement according

to a first improved embodiment of the present invention;

- Figure 4 is a view showing symbolically a combination of component parts of a through-flow heater tube arrangement according to a second improved embodiment of the present invention;

- Figure 5 is a view showing symbolically a combination of component parts of a through-flow heater tube arrangement according to a third improved embodiment of the present invention.

With reference to Figures 1a and 1b, a through-flow heater tube according to the prior art comprises a conduit 1 adapted to convey the fluid to be heated, one or more electric heating elements 2 wound round said conduit and energized through a current regulation device, preferably a Triac 3, a heat-sink arrangement 4 to cool-down said Triac, and driving and control circuits arranged on an appropriate board 6 mounted outside, these circuits being adapted to receive electric signals, process them, and send appropriate driving signals to said Triac.

It should be noticed that such a Triac could in fact be replaced with an appropriate relay; however, owing to considerations of long-term life duration and functional constraints, the use of a Triac is actually preferred.

The Triac itself is connected to the heat-sink arrangement 4, which, from a construction point of view, is in turn part of an appropriate board containing said driving and control circuits 5.

Branching out of said Triac there are of course provided electric connections 7 that connect the power-supply mains with said electric heating elements.

Figures 1a and 1b are shown to schematically and symbolically illustrate such an embodiment according to the prior art.

According to the present invention, as illustrated in Figures 2 to 5, the heat-sink arrangement 4 is on the contrary placed in close contact with the outer surface of the conduit 1, while the Triac keeps of course being connected to said heat-sink arrangement.

As a result, the physical position of said two members changes in a radical manner, since they become an integral part of the conduit.

In particular, the heat-sink arrangement 4 may even be of a markedly reduced volume and size, since the task that it has to perform in this case is no longer to dissipate heat in air, but rather to form a means for transferring said heat to the conduit 1, which therefore becomes the actual heat-sink.

The advantages offered by this first solution are plainly apparent: in the first place, the heat-sink arrangement is no longer a dedicated component part to be processed or manufactured specifically or separately. Quite on the contrary, by suitably shaping and forming the conduit it can be obtained integrally, so that such a separate component part can even be practically omitted. In the second place, the heat wasted by the Triac is almost totally intercepted and collected by the conduit, which therefore is able to transfer such a heat emitted by the Triac directly on to the fluid flowing therethrough, thereby appreciably improving the thermal efficiency of the overall assembly.

Anyway, such a solution even enables a further major advantage to be reached: going back to the afore-considered prior-art solution (Figures 1a and 1b), it can be noticed that the various component parts of the control circuits are substantially arranged on the same board

that is used to also carry the Triac. Since quite elevated currents are generally flowing through the latter, it can be quite clearly appreciated that this may cause interferences to be radiated on to the component parts arranged close by therearound, which are usually not shielded and are powered at low currents and voltages.

In order to do away withy such a kind of a drawback, all it takes is to apply the Triac onto said heat-sink arrangement 4 (see Figure 2), while on the other hand leaving the other component parts of the driving and control assembly mounted on an appropriate board 11 of their own.

Since such a board 11 is located at sites that are usually distant from said heating conduit, the really non-negligible result is hereby obtained of a distinctly reduced vulnerability to self-induced disturbances.

However, although quite efficient and improved over prior-art solutions, the described configuration still has a drawback in that the power line 13, which is connected to the power supply mains, is still provided to pass across the above-mentioned control board 11.

Such a constraint entails a problem in that, in the case of a change in the power-supply voltage, said control board 11 cannot be used any longer, thereby putting the penalty of having to produce a special kind of control board for each different power-supply voltage.

In order to solve this problem, the improvement is implemented which consists in adopting the solution that is illustrated symbolically in Figure 3, where it can be noticed that the power-supply voltage to the Triac 3 is carried directly from the power-supply mains via the connection 14, while fully omitting the intermediate passage through

the board 11 of Figure 2.

In a most advantageous manner, this also offers an opportunity in that, if the control to the Triac is obtained with a low voltage, e.g. at 12 V as a common value, said board 11 can be omitted altogether in all those cases in which there is provided a low-voltage source capable of being suitably modulated and, as a result, adapted to control and drive the Triac 3 according to the required sequence through an appropriate independent circuit 15.

An alternative solution might even be the one calling for said circuit 15 to be supplied with a low voltage in a simple, practical, low-cost and independent manner by means of a small battery of a portable-type.

Accordingly, the invention and the afore-cited improvements can be readily appreciated to be such as to allow for a maximum extent of flexibility in the use of a through-flow heater tube, owing to the latter being capable of being supplied independently of the power-supply line voltage and, furthermore, a dedicated control board not being strictly needed.

This in fact enables a through-flow heater tube to be made as a functionally and constructionally autonomous and standardized assembly; similarly, it may be even thought of making a circuit 15 in a fully standardized manner. This would sum up to the real possibility of having through-flow heater tubes and the related control circuits as self-contained component parts that are individually and independently available on the market, thereby improving the interchangeability thereof and avoiding a specific, and therefore poorly flexible and definitely expensive design of such parts.

Finally, a further improvement of the present invention consists in

placing an appropriate temperature sensor 16, preferably of the NTC- or PTC-type, in a heat-exchange relationship with said conduit or said heat-sing provision (see Figure 4).

This sensor 16 is adapted to send an appropriate signal along a related connection 17 (signal bus) that connects it to said board 11 (in the sense that it is adapted to modify a current flowing through it).

The same board 11 and the related driving and control circuits 5 are reached also by a third connection 18 that is adapted to carry a related signal, such as for instance a signal corresponding to a different temperature.

Said circuits 5 are therefore made adapted to compare, even at different moments, said signals flowing in from the respective connections 17 and 18, and to carry out a corresponding processing of the result of such comparisons, the outcome of which is a particular control signal to be sent to the Triac.

The solution that has been described above may find advantageous applications in a number of cases and circumstances, but above all in a case of automatic diagnosis that will be described below.

If the fluid to be heated is caused to re-circulate in a tub or vessel of an adequate capacity, then, when the heater is switched on, it will immediately heat up to a rather high temperature, which is in all cases measurably higher than the temperature of the fluid in such a tub or vessel.

If a comparison is made of the temperature of the fluid in the tub or vessel with the temperature on the heater tube after a certain time from the heater having so been switched on, these temperatures will

turn out as being still different, since, owing to the thermal inertia of the fluid, the temperature thereof will never be able to change at the same rate as the temperature of the heater tube and, therefore it will in this case be possible to conclude that the heater tube is operating correctly.

Otherwise, if the temperature of the liquid in the tub or vessel is after a certain time, as determined experimentally or in any other suitable way, found to be equal or close to the temperature measured by the temperature sensor 16 on said heat-sink arrangement 4, i.e. the temperature of the heater tube, it will be possible to certainly conclude that there is no heat transfer taking place from the tube to the water in the tub or vessel and, therefore, some of the component parts of the heater tube is no longer operating correctly.

A further improvement, as on the other hand this is suggested by the general technique itself, is based on interposing a well-delimited board 19 between the outer surface of said heat-sink arrangement and the component parts associated thereto, i.e. the Triac and the sensor 16, as illustrated schematically in Figure 5, in order to make said component parts easier and more convenient to mount.

Such a board 19 shall of course have adequate heat-conductivity properties, while on the other hand ensuring good electrical insulation. Anyway, the selection of a proper board having such properties is fully within the abilities of those skilled in the art. Furthermore, the kind of processing taking place in said driving and control circuits 5 may be such as to take the thermal effects of said interposed board 19 into due account.

CLAIMS

1. Through-flow heater tube comprising:

- a conduit (1) adapted to convey the fluid to be heated,
- one or more electric heating elements (2) wound round said conduit and energized by a current regulation device, preferably provided in the form of a Triac (3),
- a heat-sink means for dissipating the heat emitted by said current regulation device,
- an arrangement of circuits (5) for driving and controlling said current regulation device,
- means adapted to supply power to said heating elements via said current regulation device (3), **characterized in that**
- said heat-sink means (4) is at least partially in close contact with said conduit, in such a manner as to establish a direct heat-exchange relationship therewith,
- said current regulation device (3) is applied on to a portion of the outer surface of said heat-sink means (4).

2. Through-flow heater tube according to claim 1, **characterized in that** said arrangement of driving and control circuits (5) is provided on a support board (11), which is separate and distinct from said heat-sink means (4) on which there is mounted said current regulation

device (3).

3. Through-flow heater tube according to claim 2, **characterized in that** the power supply voltage is directly connected to said current regulation device (3), while it is not connected to said driving and control circuits (5).

4. Through-flow heater tube according to any of the preceding claims 1 to 3, **characterized in that** on said conduit (1) there is provided a temperature sensor (16) in a heat-exchange relationship with either said heat-sink means (4) or directly with said through-flow heater tube (1), and that said temperature sensor (16) is connected independently to said arrangement of driving and control circuits (5).

5. Through-flow heater tube according to claim 4, **characterized in that** said arrangement of driving and control circuits (5) is adapted to compare the signal coming from said temperature sensor (16) with a second different signal received after a pre-established period of time, to perform a processing the result of said comparison, and to send to said current regulation device (3) a corresponding signal depending on the outcome of said processing.

6. Through-flow heater tube according to any of the preceding claims, **characterized in that** between said current regulation device (3) and/or said temperature sensor (16) there is provided a support layer of electrically insulating material (19) having properties of high heat conductivity.

FIG. 1a

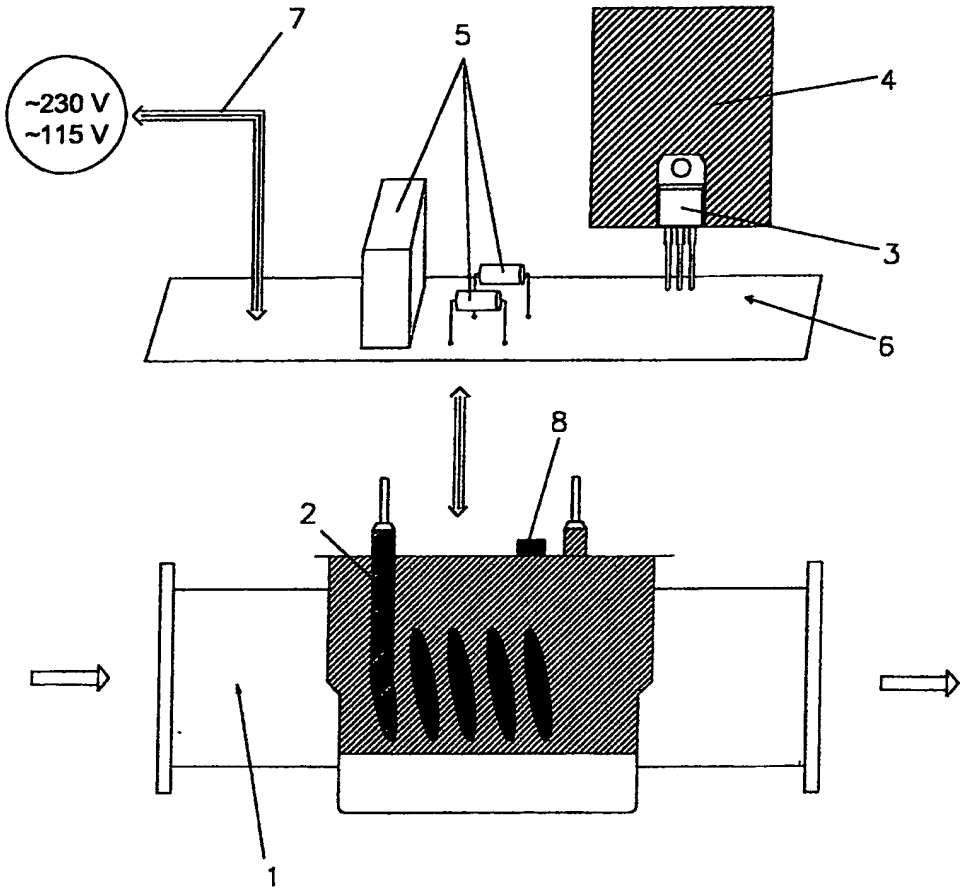

FIG. 1b

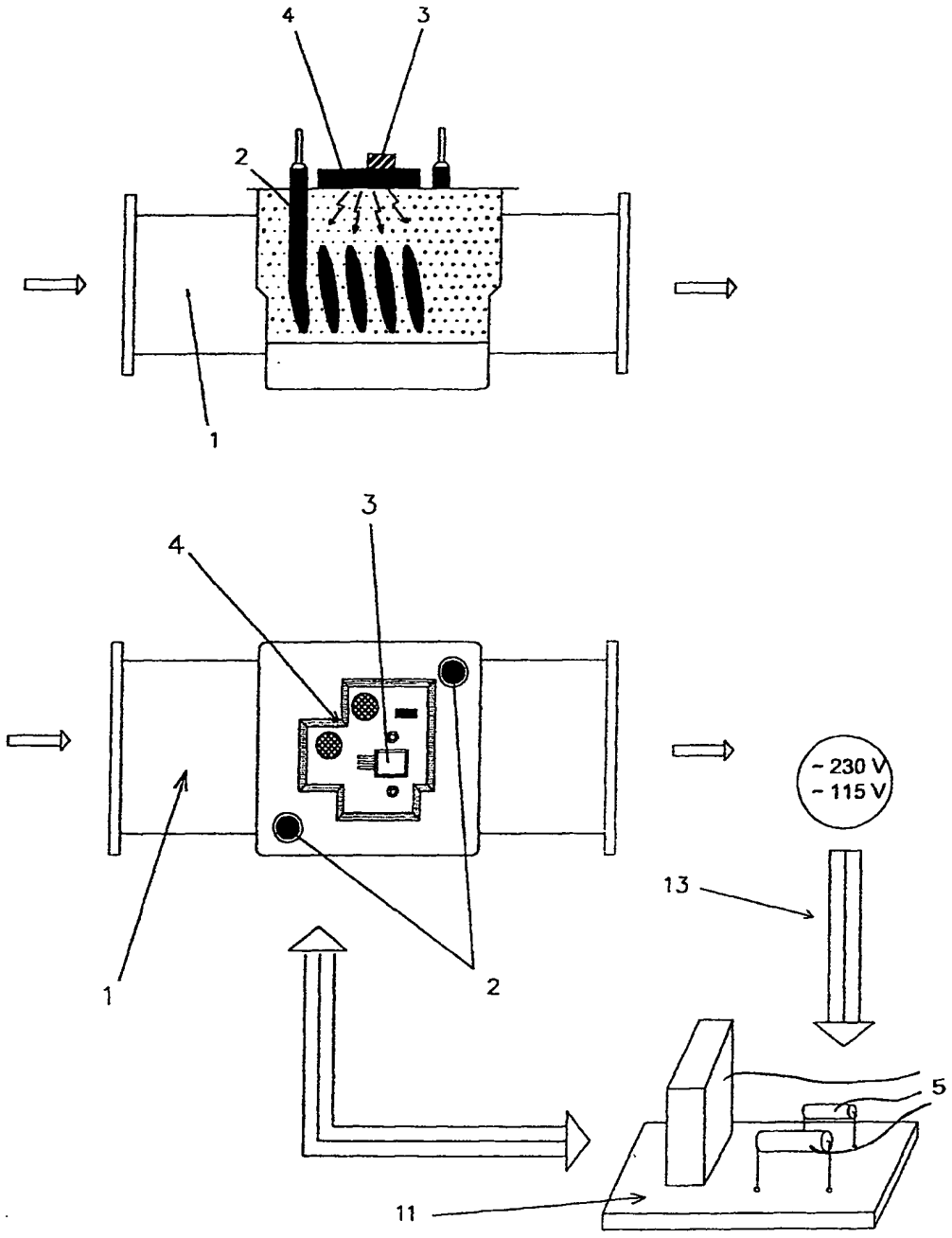

FIG. 2

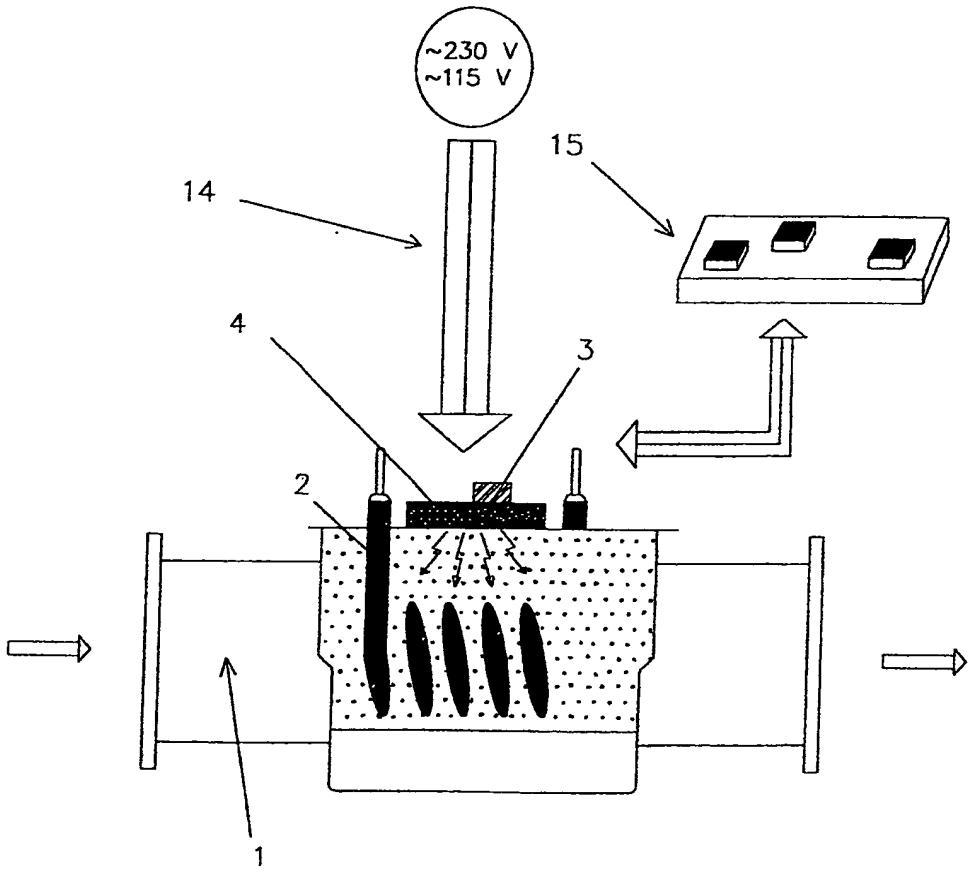

FIG. 3

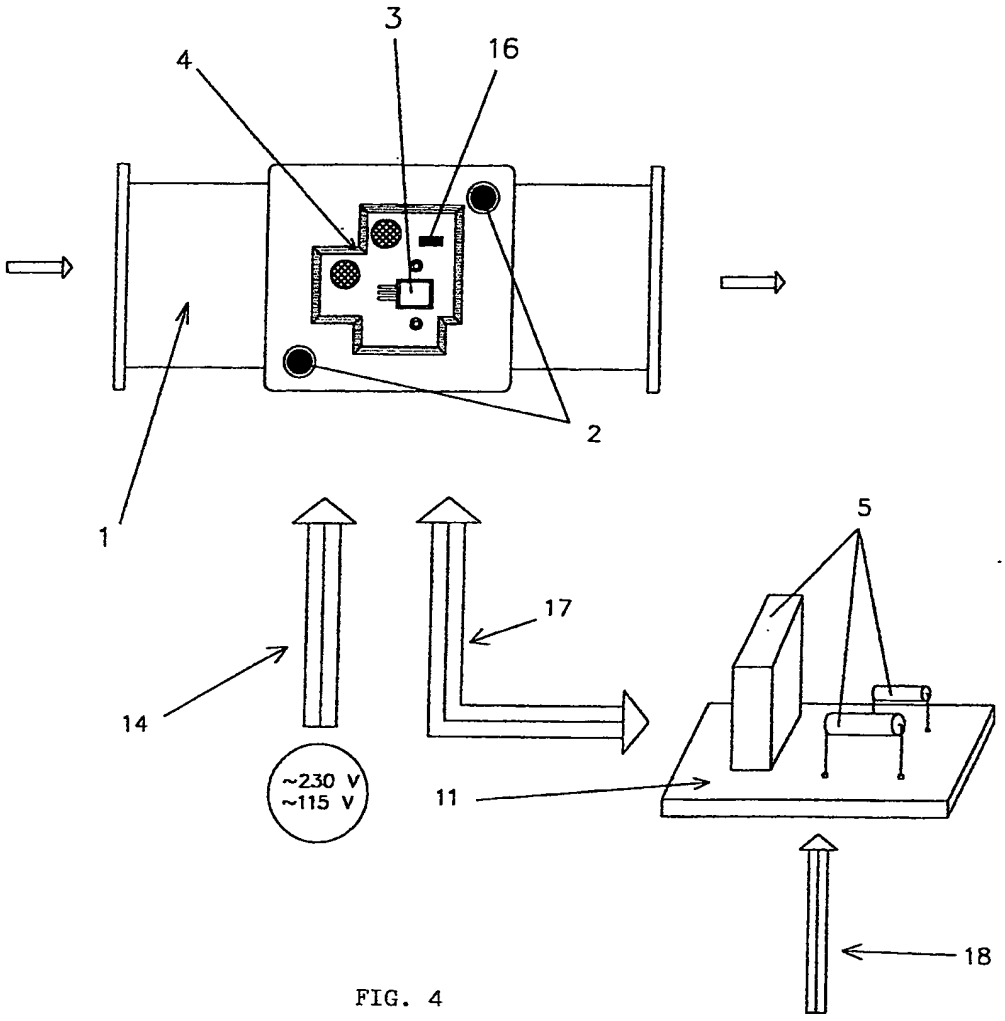

FIG. 4

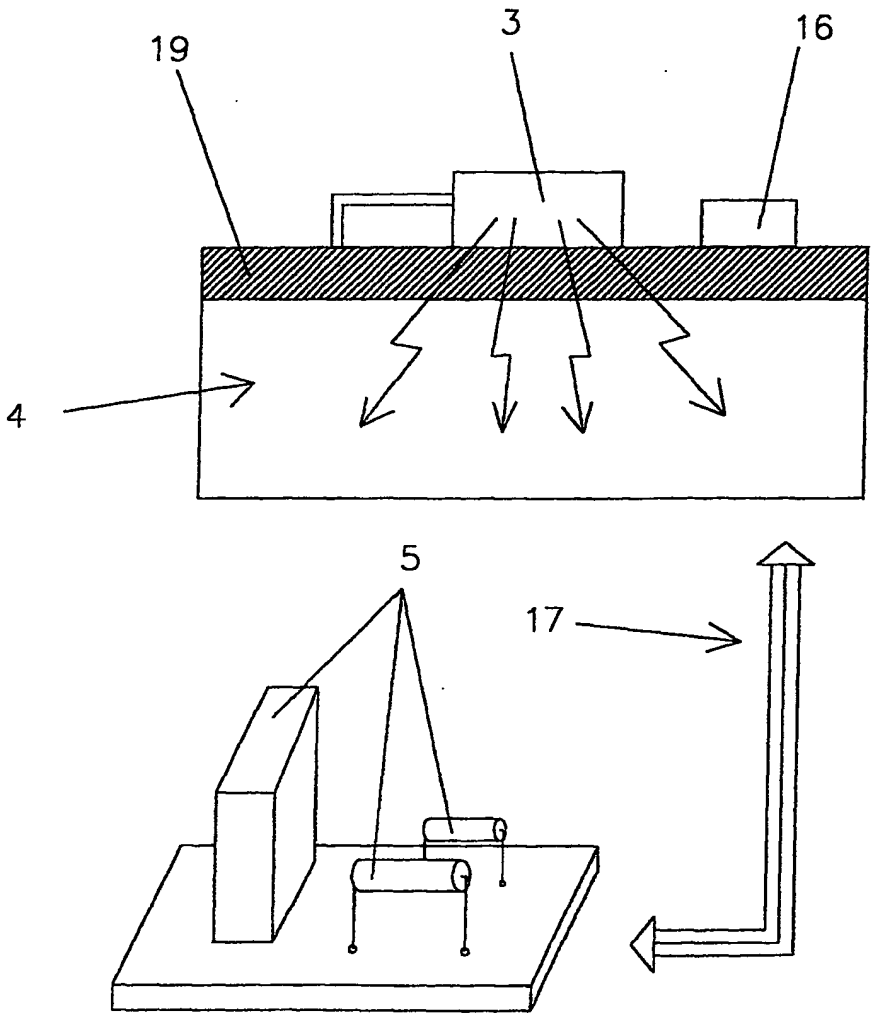

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/09925

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B1/02 F24H1/10 F24H9/20 G05D23/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B F24H G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 10071 A (N T W ENTERPRISES INC) 11 June 1992 (1992-06-11) the whole document	1-6
X	US 5 216 743 A (SEITZ DAVID E) 1 June 1993 (1993-06-01) the whole document	1-6
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X	US 4 029 937 A (RUSSELL ROBERT G) 14 June 1977 (1977-06-14) abstract; figures 1-7 column 15, line 48-65 column 16, line 12-15 column 16, line 25-44	1-6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Garcia, J

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/09925

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 019 690 A (KNEPLER JOHN T) 28 May 1991 (1991-05-28) abstract; figures 1-12 column 5, line 1-9 claim 1	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/EP 03/09925

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